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SOLAR RADIATION AT PARSONS, WEST VIRGINIA

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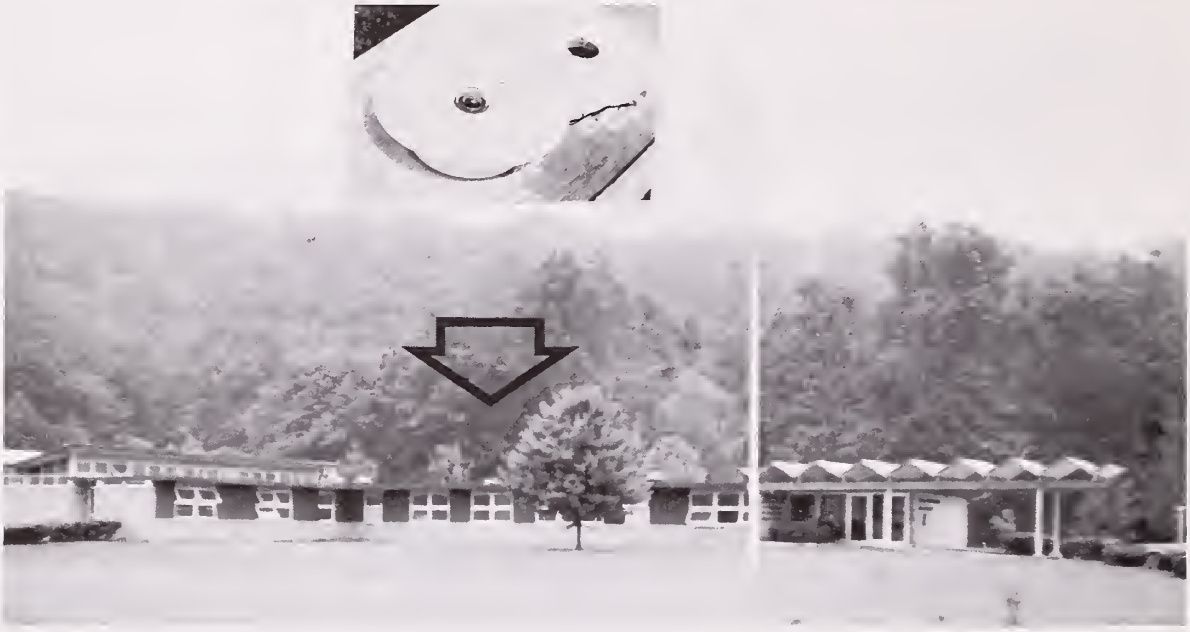
Abstract. Twelve years of solar radiation data, measured with a Kipp-Zonen pyranometer, were recorded near Parsons, West Virginia. The data agree well with calculated values of potential and average radiation for the vicinity and are applicable to the central Appalachian region.

Since 1965, incoming shortwave radiation has been measured at the Northeastern Forest Experiment Station's Timber and Watershed Laboratory near Parsons, West Virginia. We know of no similar long-term measurements in the central Appalachian region, within perhaps 150 miles from the Laboratory. A better understanding of solar radiation is needed to optimally manage forest resources. Moreover, the developing shortages of fossil fuel stimulate interest in solar radiation as a non-polluting source of fuel to help meet man's ever increasing energy needs.

The Kipp-Zonen pyranometer[1] was chosen for these measurements. It was considered

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Figure 1.—The Kipp-Zonen pyranometer is located near the center of the roof of the Northeastern Forest Experiment Station's Timber and Watershed Laboratory near Parsons, W. Va. (lat. 39°06'N.; long. 79°40'W.).



more sensitive and less costly than competitive instruments, and satisfactorily shielded from reflected light. From the Laboratory roof, surrounding low ridges form a skyline to the pyranometer about 6° above horizontal (Fig. 1). Daily radiation is traced on strip charts by a Leeds & Northrop Speedomax H Recorder. An attached totalizer records langleys (calories/cm^2/min)[2] for 24-hour periods. Monthly and yearly totals have been compiled from these data. Pyranometer calibration has been checked 3 times since its installation, by a potentiometer with factory calibration or by a pyroheliometer calibrated at another laboratory.

During January 1978, daily totalizer data were checked against corresponding strip chart records. Anomolies were corrected by planimetering areas beneath the strip chart traces, then converting those areas to langleys per day. The verified records were transcribed to tape, then processed on an IBM model 5100 desktop computer. All of the following results were derived from data so processed.

[2]1 langley = 4.184×10^4 joules per square meter.

RESULTS

Mean daily radiation, with standard deviation, was calculated for each month. These data, with highest and lowest daily radiation observed for the month, are plotted in Figure 2. Note that all of these values peak during June, when amplitude also is greatest. Radiation values and their amplitude were, of course, least during December.

Mean monthly radiation, with standard deviation, also was calculated (Fig. 3). Note that standard deviation and extreme values of monthly radiation cluster more closely about the mean curve than the daily values in Figure 2. Here, too, amplitude was greatest in months with the most radiation.

Variation among annual data was even less; maximum (114,143 langleys) and minimum (102,427 langleys) values varied less than 8 percent from the 12-year mean annual radiation (105,475 langleys). This relative lack of variation illustrates the stability of solar radiation as an index of climate. Mean annual temperature, however, is the more widely used index because it more easily measured, and, therefore, data are far more abundant.

Figure 2.—The range of measured daily radiation at Parsons, W. Va. Mean daily values are plotted as a curve; about two-thirds of the daily values fall within limits around the mean as indicated by standard deviation. Minimum and maximum values plotted for each month are least and greatest daily radiation observed for that month during the 12-year period of record.

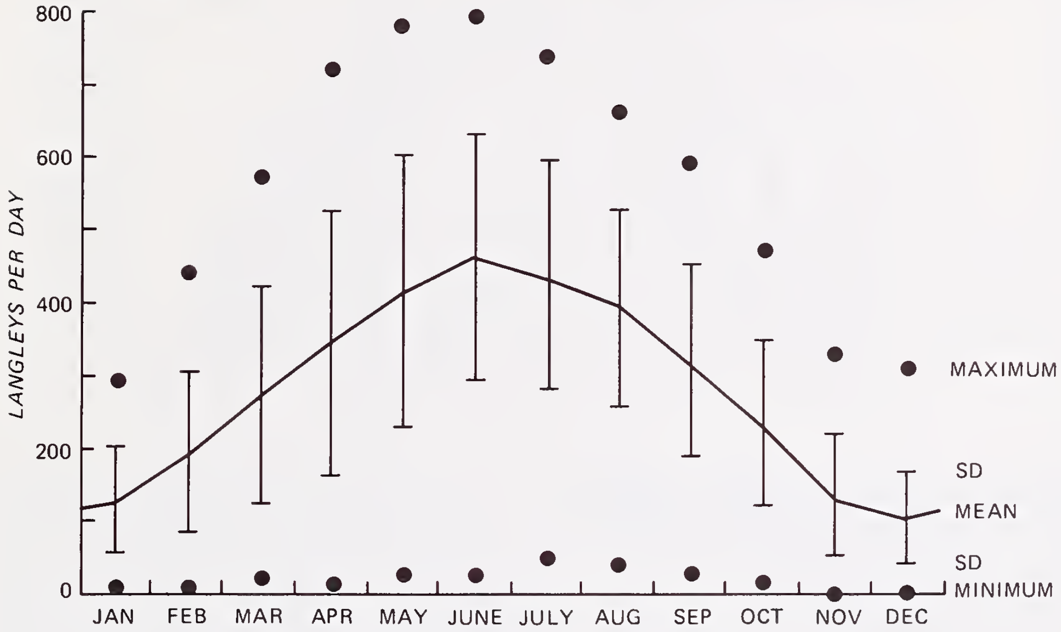


Figure 3.—The range of monthly radiation at Parsons, W. Va. Mean, standard deviation, and highest and lowest values observed are plotted as in Figure 2.

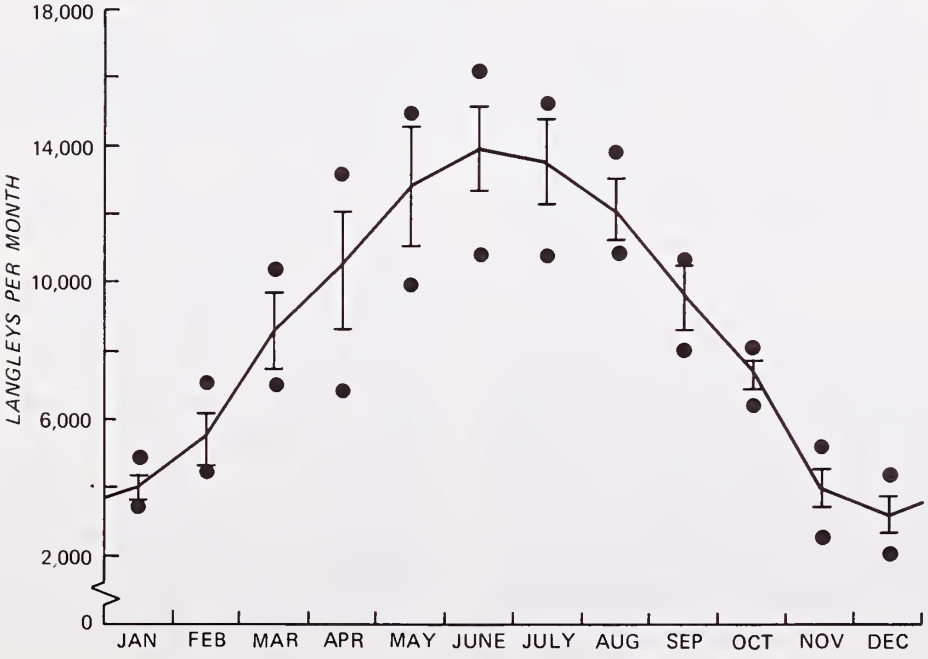
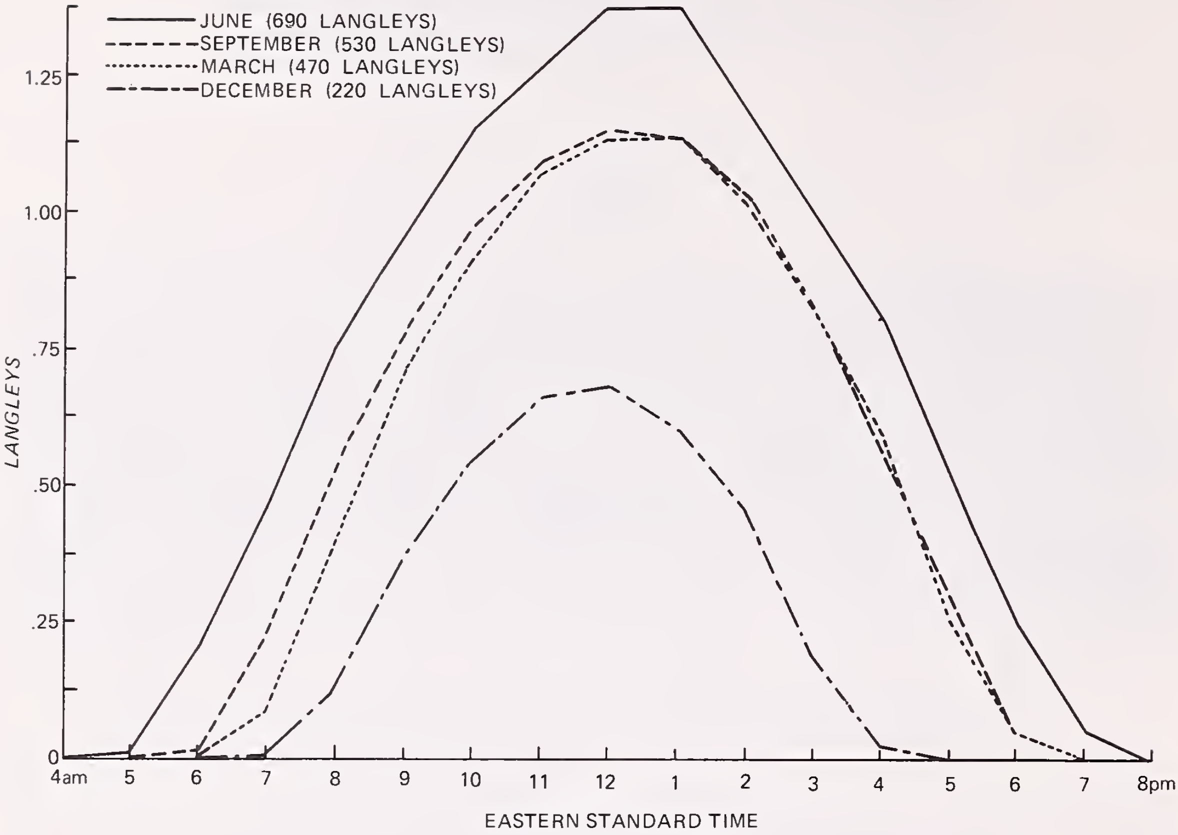


Figure 4.—These daily inputs of solar energy approach the upper limits likely at Parsons during solstice and equinox months.



Clear days (those with less than 1 hour of cloudiness after the usual morning fog) are relatively scarce at Parsons. On the average, there are 5 clear days in October, 3 each in April and May, 1 each in June and December, and 2 in each of the remaining months. In Figure 4, solar radiation was averaged for 10 clear days during June and December to illustrate maximum energy input likely at each solstice; solar radiation also was averaged for March and September to show the maximum likely at each equinox. The greater energy input during the September equinox probably reflects morning skies generally clearer than those of March.

The data in Table 1 provide a basis for probability statements about daily radiation during given months: (a) 700 or more langleys are likely on one day only, in May and June; (b) at least 100 langleys are probable every day in July and August; (c) radiation in excess of 300 langleys is unlikely November through January; (d) 500 or more langleys are likely for half of the days in June.

A Gunn-Bellani radiation integrator, placed in a forest opening about 2 miles east of the Timber and Watershed Laboratory, provided data for May through October from 1959 to 1965. Results with this instrument, measuring radiation on a spherical surface, differed somewhat from the results with the Kipp-Zonen instrument, by which radiation was measured on a horizontal surface. Pereira (1959) reported high linear correlation between these instruments. Results for both instruments were similar May through July but Gunn-Bellani data were higher August through October (Table 2). These comparisons must

Table 1.—Probable number of days per month in which solar radiation equals or exceeds the stated amounts.

Radiation (langleys)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
	Days											
700					1	1						
650				1	3	3	2					
600				2	6	7	5	2				
550			1	5	9	11	8	5	1			
500			2	8	11	15	12	8	3			
450			5	11	14	18	16	12	6			
400		1	8	13	17	20	19	16	10	2		
350		3	11	16	19	23	21	19	15	6		
300		7	13	17	21	24	23	22	18	11		
250		2	15	19	23	26	25	25	20	16	3	1
200	8	15	19	22	25	27	27	27	23	19	8	4
150	12	18	20	24	27	28	28	28	25	21	13	9
100	17	21	25	26	28	29	30	30	28	24	17	14
50	23	26	29	29	30	30	30	30	30	28	24	22
0	30	30	30	30	30	30	30	30	30	30	30	30

be interpreted cautiously because they were obtained at different times and places.

How valid are Kipp-Zonen data? One kind of check concerns the greatest amounts of radiation possible per day at the latitude (39°06′N.) of Parsons (Table 3). Ideally, the observed maxima will not exceed computations of potential or clear sky values. These computed values, however, are only as valid as the assumptions built into them; for example, assumptions of atmospheric turbidity may or may not prove valid for all occasions. The observed maximum radiation for every month except February was close to or less than one of the computed values. We believe that the observed value for February (424 langleys) was real. The chart trace for that day (2/26/70) was exceptionally high and smooth, suggesting a bright and cloudless day. And the day length so late in February would considerably exceed the average day length for that month. The next highest value for February (383 langleys) was close to computed values.

Table 2.—Results of radiation measurements by two recorders

Month	Average radiation	
	Kipp-Zonen	Gunn-Bellani
	Langleys/day	
May	417	412
June	462	454
July	440	449
August	399	442
September	322	376
October	239	265

Table 3.—Measured versus computed daily maxima of radiation at Parsons, W. Va.

Month	Observed maximum	Potential direct beam[1]	Clear sky radiation[2]
	Langleys/day		
January	287	271	290
February	424	387	380
March	516	539	530
April	678	691	670
May	782	807	740
June	796	867	790
July	741	861	750
August	668	771	690
September	593	626	570
October	473	472	430
November	334	336	350
December	260	225	270

[1] Unpublished report on file at Timber and Watershed Laboratory, Parsons, per Fons (1961).

[2] From Chang et al. (1976), Table 2.

Table 4.—Measured versus computed daily average radiation at Parsons, W. Va.

Month	Measured at Parsons	Horizontal surface radiation[1]	Average for Northeast[2]
	Langleys/day		
January	130	160	125
February	195	220	225
March	275	320	300
April	348	430	350
May	417	510	450
June	462	560	525
July	440	540	525
August	399	480	450
September	322	400	350
October	239	290	250
November	134	210	125
December	107	150	125

[1] From Chang et al. (1976), Table 1.
[2] From Reifsnyder and Lull (1965).

A second kind of check, average daily radiation, also has been estimated for conditions of atmospheric turbidity characteristic of northern West Virginia. Two such estimates are compared with measured daily values for Parsons (Table 4). Measured amounts for every month except January are lower than computed values. As with clear sky radiation, there are large differences among computed values.

EVALUATION

There is no absolute check for evaluating the accuracy of this radiation record. There were consistent variations between autumn records for the instruments used, but they were exposed at different times and places (Table 2). Variations among computed values of daily maximum and average radiation often were of greater magnitude than variations between measured and computed radiation (Tables 3 and 4). On the basis of these checks, we conclude that the radiation data for Parsons are reasonably close to true values.

For how extensive a region are the Parsons radiation data representative? Climatic maps (USDA 1941) help identify the applicable region. They show that north-central West Virginia has some of the cloudiest, foggiest, least sunny weather in eastern United States. Our data seem most appropriate for the mountainous parts of West Virginia, western Maryland, and western Pennsylvania. They may be useful for all of West Virginia, western Pennsylvania, southern New York, parts of eastern Kentucky and Ohio, and parts of western Virginia and North Carolina. They are not representative of climate outside the more mountainous areas of the Appalachian region.

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